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Marksmanship Trainer Performance Using an Auditory Signal Warning of Simulated Laser Exposure

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Marksmanship Trainer Performance Using an Auditory Signal Warning of Simulated Laser Exposure--Mastroianni **et al.**

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Previous research has demonstrated decrements in marksmanship accuracy on a WEAPONEER trainer when LEDs (light emitting diodes) were used to simulate scanning and attack lasers. In this study subjects engaged targets that displayed either no lasers, a scanning laser only, or scanning-plus-attack lasers. The scanning laser was simulated with an LED; the attack laser was simulated with a buzzer. Marksmanship performance did not decline as much on scanning alone trials as was the case in previous studies which used visual cues for both simulated lasers. Since overall marksmanship was better with our group of subjects, sampling differences may account for the results. Diminished resource competition between the marksmanship tasks and the laser-monitoring task may have contributed to the performance improvement with auditory cues.

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ABSTRACT

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INTRODUCTION

Experiments conducted in this laboratory have demonstrated that simulated laser exposure can affect performance on a WEAPONEER marksmanship trainer (1, 2). Earlier studies of this phenomenon have used visual cues to represent the simulated laser, in the form of visual warning signals (LEDs) mounted on the silhouette targets. This simulation adequately represents the situation which a soldier encountering visible lasers might face. Invisible lasers (such as lasers operating in the infrared region of the spectrum) are also a significant personnel threat. Automatic sensing systems can be developed to detect and warn of harmful laser exposure, much as chemical agent detection and warning systems are now employed.

The configuration an automatic sensing system might take could vary considerably depending on many factors. One significant but often underemphasized aspect of the design is the sensory modality used to receive the warning signals generated by such a device. The earlier experiments we conducted all used visual warning signals (LEDs). What might be the consequence of using an auditory signal to cue the subject to laser exposure? Research in the workload literature (3) has suggested that, when multiple tasks are competing for resources (such as a primary marksmanship task and a secondary laser-monitoring task), the compatibility of the processing and response demands made by the respective tasks influences the performance degradation observed.

In this case, the response demands cannot be altered, as engaging and killing the target must be accomplished. The primary task, marksmanship, makes heavy demands on visual processing resources. As opposed to a visual warning signal, an <u>auditory</u> warning signal does not compete with the primary task for scarce vision-processing resources and, thus, is more compatible with it. The purpose of this study was to substitute an auditory warning for the LEDs previously used, to test the hypothesis that diminished for competition resources would lead to better performance on the primary marksmanship task than that observed in earlier studies using visual cues.

METHODS

Subjects: Subjects were 10 soldiers assigned to Letterman Army Institute of Research, ranging in age from 18 to 33. There were 7 males and 3 females in the sample. Subjects were either emmetropic or wore correction to 20/20 acuity. Subjects participated in the experiment voluntarily and were offered the incentive of a 3-day pass if their marksmanship performance was in the top 50% of the subjects tested.

Apparatus: The apparatus used in the experiment was a modified WEAPONEER marksmanship trainer. The WEAPONEER has been described elsewhere (4). The apparatus was modified as described in Mastroianni et al. (1, 2) to simulate a scenario in which enemy soldiers might possess man-portable anti-personnel laser weapons (2). One change was made to the device for the purposes of this experiment: a Sonalert buzzer was installed in place of the red LED mounted on the right shoulder of the silhouette targets.

Procedure: The three trial types described in Mastroianni et al. (1) were also used in this study. In scanning- and attack-laser (Type 3) trials, however, the red LED indicating dangerous laser exposure was replaced with the activation of the buzzer. The duration of the buzzer sound was of the same length as the red LED in the earlier studies.

Subjects participated in three 45-trial sessions. The first session was a practice session and the last two were experimental sessions. The experimental sessions were conducted the day after the practice session. On each day, subjects were permitted to zero the weapon on the 25-m target before firing. In each session, three types of laser presence were encountered: no laser, scanning laser only, or scanning-plus-attack laser. Fifteen trials of each type were presented in randomized order. The fifteen trials of a given type consisted of five presentations of each of the three targets (100 m, 250 m high-contrast, 250 m low-contrast), also presented in randomized order. Randomization was accomplished using a BASIC program to produce permutations of the appropriate series.

After completion of each 45-shot series, subjects were given feedback on their performance and allowed a few minutes to rest. At the conclusion of the experiment subjects were thanked for their participation and told that they would be notified of whether or not they had been awarded a pass (as a result of scoring in the top 50% of the firers) in a few days.

The raw dependent measure used in this experiment was the hit, miss, or late score generated by WEAPONEER for each shot. These scores were used to compute a percent-hit score for each subject, in each condition of the experiment. Data were analyzed using ANOVA.

RESULTS

An ANOVA on the mean percent-hit scores showed a significant effect of trial type ($F(2, 18) = 18.9$, $p < .001$) and a significant trial type by target interaction ($F(4, 36) = 10.3$, $p < .0001$). Mean percent-hit scores for each target and laser-presence scenario are shown graphically in Figure 1. The exceptionally poor performance on "scanning-plus-attack" trials (Type 3) for the 100-m target is consistent with the results of previous studies (2) and probably reflects the extreme difficulty in engaging a target in such a short time. The 100-m target is only exposed for 2 s, and on Type-3 trials the subject is required to hit the target before the buzzer sounds 1.5 s into the exposure. The poor performance on Type-3 trials contributed to the lack of a significant main effect of target, as the overall mean for the 100-m target, which otherwise was considerably higher than the means for the two 250-m targets, was lowered by the poor performance on Type-3 trials.

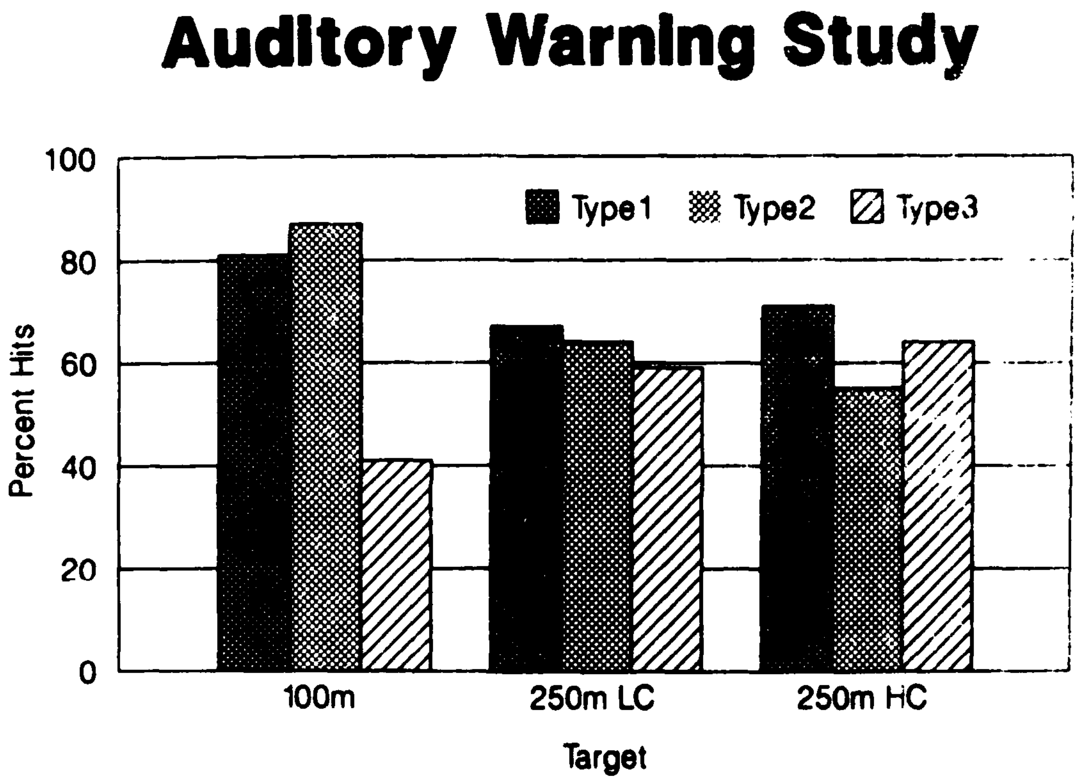

Figure 1. Histogram Showing Mean Percent Hits for Each Target on Each Trial Type.

In general, the results of this study show better performance on Type-2 trials than in earlier research. While there is some reduction in Type-2 trial performance, post-hoc Least Significant Difference tests (5) showed that Type-3 trials were significantly different from Type-1 and -2 trials, but that Type-2 trials were not significantly different from Type-1 trials (Figure 2). This result is comparable to

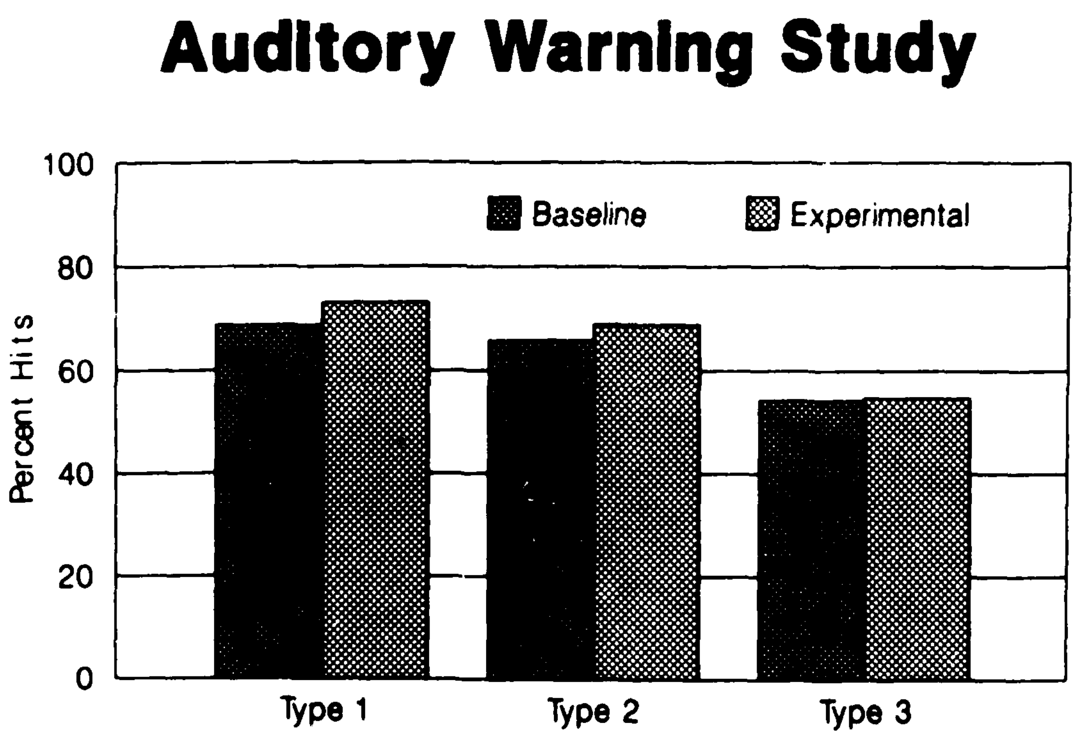

Figure 2. Histogram Showing Mean Percent Hits for Each Trial Type Arranged Across Target.

the low-density laser group performance reported by Mastroianni et al. (2). In this earlier study, soldiers who were exposed to relatively few Type-3 trials (a low-density laser group) showed a much smaller change on Type-2 trials as compared to soldiers who experienced a large proportion of Type-3 trials (a high-density laser group). Mean percent-hit scores in the present study were also larger than in earlier studies, particularly for the two 250-m targets. Figure 3 shows the relative performance of comparable baseline trials in the present

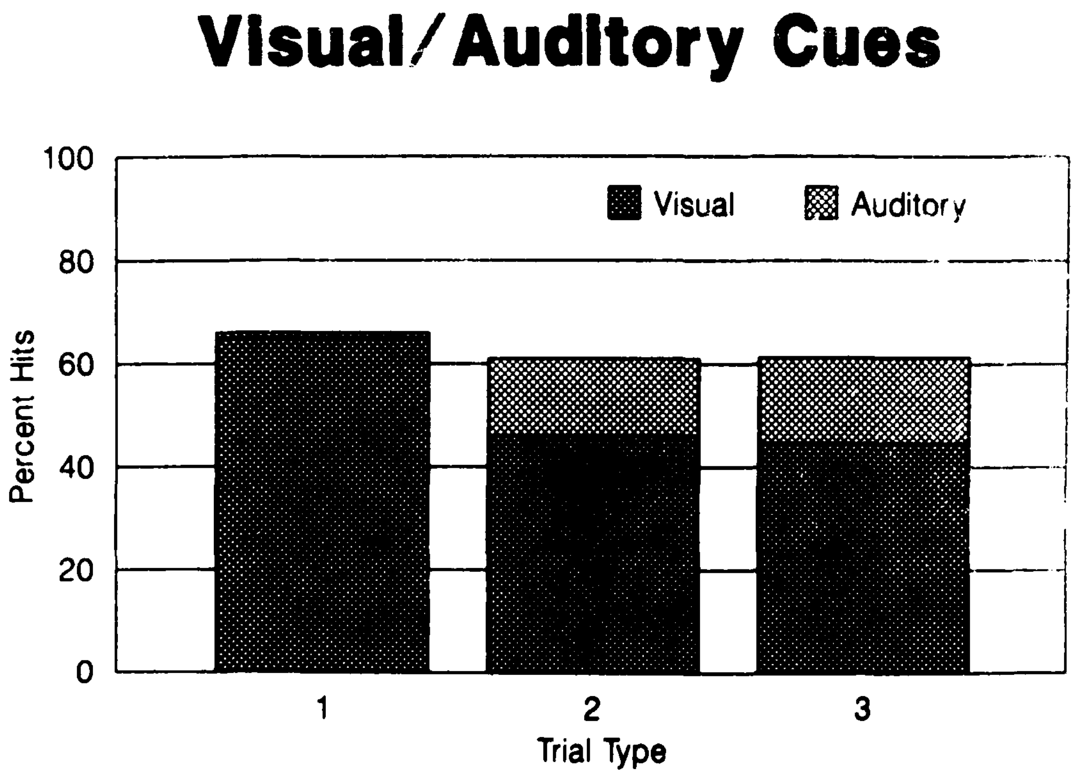

Figure 3. Stacked Histogram Showing a Comparison of Baseline Data from this Study and Data from the Baseline Condition of mastroianni, King, Zwick and Stuck (1988), a Similar Study Which Used Visual Laser Cues.

study and in the visually cued trials of Mastroianni et al. (2). The auditory cue seems to lead to better performance overall than the visual cues. It should be remembered that no attempt was made to match the beginning marksmanship ability of the subjects in this study with that of the group that was used by Mastroianni et al. (2); therefore, these differences may well be primarily due to sampling differences and not to the modality of the cue.

DISCUSSION

The results reported here support and extend previous findings demonstrating psychological effects of simulated laser exposure. The magnitude of the decrements in performance caused by strategy changes related to the laser scenario was small in this study relative to that of the decrements observed in previous studies (1, 2). Whether this difference is due simply to individual differences in the subjects who participated in the two studies or represents a genuine consequence of the cue modality used cannot be said with confidence given the available data. The mean performance of the subjects in the present study was considerably higher than in the earlier studies; this apparent difference in marksmanship ability at the outset of the study may explain the differences observed.

Since it is possible that automatic laser sensor and warning systems might be deployed on vehicles or aircraft, the method of cuing or alerting the operator to the presence of a laser might be important. The considerable literature on operator workload, developed primarily in the field of human factors in aviation, seems to suggest that the optimal cue modality would be one that competes least with the primary task for processing resources (3). In this case, it might be that the auditory cue is associated with better primary task (marksmanship) performance because monitoring the auditory cue does not divert visual resources away from the target engagement process. When visual cues were used in the earlier studies, competition for visual processing resources between the marksmanship task itself and the task of monitoring the laser cue LEDs may have contributed to the observed decrements in performance.

CONCLUSION

Although this experiment does not constitute a definitive study of the modality of laser cuing in this paradigm, it does suggest a direction for further research. Auditory cuing may be a way to reduce the deleterious effects of simulated laser exposure documented in earlier studies.

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